Assessment of Soil Salinity and Irrigation Water Quality of Chanchaga Irrigation Scheme I, Minna, Niger State

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Abstract— The extent to which salinity is increasing in arid and semi-arid regions recently has become a concern in irrigation and non-irrigation land. In view of this, the study evaluated soil salinity and irrigation water quality at Chanchaga Irrigation Scheme I, Minna, Niger State with the aim of assessing the soil fertility status and irrigation water source of the scheme. The study took soil samples at 0 - 30cm depth from irrigated and non-irrigated plots and water was taken from the main point of the border irrigation system. Both soil and water sample collected were subjected to laboratory analysis. The study determined sodium absorption ratio and exchangeable sodium percentage of soil and water parameters analyzed in the laboratory. The Levene's test for equality of variances was performed on the concentration of the parameters analyzed in both soil (irrigated and non-irrigated plot) and water of the scheme. The study reveals that the sodium concentration was found higher in the irrigated plot than control plot and the EC and SAR values of the irrigated plot was classified as sodic. The SAR and other exchangeable values in both irrigated and non-irrigated plot have equal variances (> 0.10) with the exception of chlorine which is significant. The level of potassium in the water was higher and sodic in nature. The study concluded that the sodium hazard in both soil and water was higher than the desirable limits. It is important to take the soil sample of the whole plots so as to examine the salt variation in the scheme

Keywords— Chanchaga Irrigation Scheme I, Irrigation Water, Physical and Chemical Properties, Soil Salinity

1. Introduction

Globally, salinization is a source of risk to soil, water and human health (Shrivastava and Kumar, 2015). It is the main problem of irrigation agriculture because it has negative impact on the stages of crop growth and restricts both phosphorus and water uptake from soil (Shrivastava and Kumar, 2015). Salt-affected soils are either saline or sodic. Saline soils are those soils with electrical conductivity above 4dS/m that affect the crops growth (Aderoju and Akomolafe, 2013). Chlorides and sulphate of sodium, calcium and magnesium are the principal elements of soluble salts. There exist two categories of salinity and these include primary and secondary salinity. The former come naturally due to accumulation of salts while the later occurs due to irrigation land or dry land.

Sodic soils refer to soils with exchangeable sodium percentage above 15, with sodium salts such as alkaline hydrolysis and sodium carbonate (Aderoju and Akomolafe, 2013). Aderoju and Akomolafe, (2013) reported that alkaline hydrolysis and sodium carbonate of salts-affected soils dissent physically, chemically, biologically, and their geographical and geochemical dispersion. Salinity is one of the severe environmental factors limiting crop productivity. It is important because most crops are sensitive to salinity caused by high concentration of salts in the land while few crops are not. Furthermore, salinization is becoming prominent factor for salinity because of evaporation phenomenon in irrigation (Shrivastava and Kumar, 2015).

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Poustini (2004) reported that increase in food demand during the last 3 to 4 decades aggravated the use of irrigation by about 300% which in turn make the use of ground water to be prominent since surface water is scarce in both arid and semiarid regions thereby increasing soil salinization. Numerous studies employed EC, SAR, ESP, and osmotic potential methods to determine the nature of soil salinization (Chemura *et al.*, 2014; Munns, 2005). Both sodium absorption ratio (SAR) and exchangeable Sodium percentage (ESP) are effective because they involve laboratory analysis of physical and chemical properties of soil and irrigation water. Adamu (2013) reported that exchangeable Sodium percentage (ESP) in Watari River Irrigation Project, Kano State was low. Ethan *et al.*, (2014) reported that the concentration of SAR at Baddegi and Edozighi irrigation scheme is low. Maina *et al.*, (2012 accounted that the mean value of EC, SAR and TDS are normal at Kano River irrigation project. Little study has shown that the soil salinity and alkalinity level in the scheme were normal. Due of this, the study is assessing the soil fertility status and water source of the Chanchaga Irrigation Scheme I for ascertaining the extent of salinity in soil and water source.

2. Materials and Methods

2.1 Description of Study Area

The study was carried out in Chanchaga irrigation scheme I and it is located at Chanchaga Local Government area of Minna, Niger State. It lies between 941' 00" N and Longitude 638' 00". The scheme was established in 1975 and it is situated behind Chanchaga main - market. The scheme has 10 hectares of land and uses surface irrigation. It is extended on the bank of river Chanchaga and uses river Chanchaga as source of water as shown in Fig 1. The scheme experiences both dry and wet seasons. The average annual temperature and rainfall were 27.5°C and 1229 mm respectively. Soils underlied by sand stones and it has loamy and sandy loam textures that are reasonably fertile and well drained. The soil has high water infiltration rates. Rice, spinach, okra, maize and sorghum were the major crops grown in the scheme.

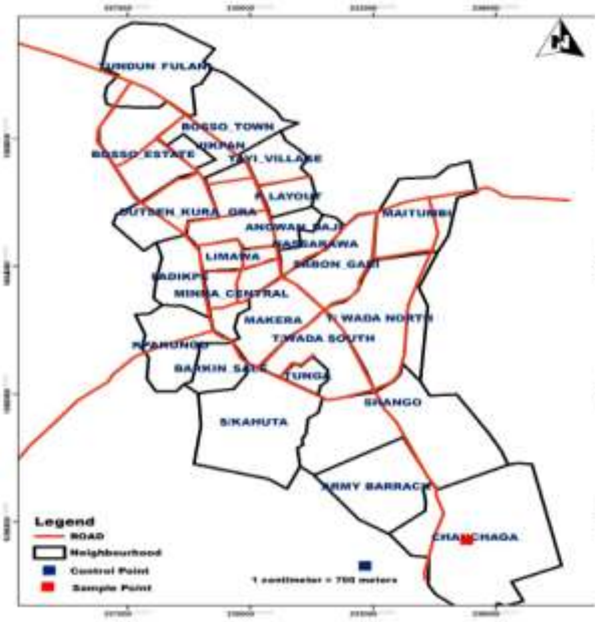

Fig. 1: Map of Chanchaga Irrigation Scheme I

2.2 Materials

The following materials were used for this study.
(i) GPS: This was used to capture coordinates of the plot.
(ii) Soil auger: This was used to collect soil samples to a depth of 0 -15 cm and 15 -30 cm.
(iii) Measuring Tape: It was used to measure the sampled plot and distance of the selected plot and the control plot.
(iv) 35cl plastic/PVC bottle: This was used to collect and transport water samples from the irrigation scheme to laboratory.
(vi) Ice domestic cooler: it was used to preserve the water samples at 4°C.

Experimental Description of the Area: The study selected a plot (8m by 20m) out of 10 hectares in the scheme because of financial constraint in subjecting numerous soil samples to laboratory analysis. In addition, this plot was taken because of the fact that it received water first during irrigation through border irrigation system. Border irrigation system components include water pump, main line, sub-main line, etc. that spread water over the field through gravity flow.

2.3 Soil Sampling

This plot was divided into two equal blocks for the purpose of soil sampling. Each block was further subdivided into four homogeneous blocks. Thirty-two soil samples were collected at 0-15cm and 15- 30cm depth on both the irrigated plot and the control plot and the sample handling was carried out as described by Okalebo *et al*., (2002). In each block, four soil samples were collected at random and mixed together to form a composite sampling. Also, control samples were collected approximately 540m away from the plot using composite sampling method.

2.4 Soil Analysis

The soil samples were collected and analyzed between 27th July and 4th August 2016 at WAFT Federal university of Technology, Minna in accordance with Ogunwale (1978). The soil parameters analyzed were pH, EC, K^+, Ca^{2+}, Mg^{2+}, Na^+ and total exchangeable bases.

2.5 Water Analysis

The water samples were collected on 27th July, 2016 at the main irrigation line on the field. The samples were kept in ice domestic cooler and transported to WAFT Federal university of Technology, Minna laboratory and stored in the refrigerator at 4°C prior to analysis. The samples were analyzed in accordance with Ogunwale (1978). The water parameters analyzed were pH, Ca^{2+}, Mg^{2+}, Na^+, HCO_3^- and Cl^-.

2.6 Method

2.6.1 Determination of sodium absorption ratio

The study used equation 1 to determine the sodium absorption ratio of both soil and water as described by Leticia *et al.*, (2015). The sodium absorption ratio was interpreted as shown in Appendix A. It is calculated as follows;

$$SAR = \frac{Na^+}{\frac{\sqrt{\{Ca^{2+} + Mg^{2+}\}}}{2}} \qquad (1)$$

Where,
SAR= Sodium absorption ratio.
Na^+, Ca^{2+}, and Mg^{2+} are exchangeable bases of sodium, calcium and magnesium cations.

2.6.2 Determination of Exchangeable Sodium Percentage

The study used equation 2 to estimate Exchangeable Sodium Percentage of both soil and water of the scheme as described by Leticia *et al.*, (2015). The **e**xchangeable Sodium Percentage was interpreted as shown in appendix B. It is calculated as follows**;**

$$ESP = \frac{Na^{2+}}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100 \qquad (2)$$

Where,
Na^+, Ca^{2+}, Mg^{2+} and K^+ are exchangeable bases of sodium, calcium, magnesium and potassium cat ions

2.7 Data Analysis

Levene's Test for Equality of Variances was performed on the data obtained from the laboratory. The results were presented in Tables 1, 2 and 3.

3. Results and Discussion

3.1 Determination of Physiochemical Properties of Soil in the Scheme

3.1.1 Soil Exchangeable Bases

Table 1 shows the mean concentration of soil exchangeable bases in Chanchaga irrigation scheme 1. For the irrigated plot, the mean values of Potassium (K^+), Calcium (Ca^{2+}), Sodium (Na^+) and Magnesium (Mg^{2+}) were 14.82, 40.0, 58.65 and 8.40 (mg/l) while that of the control plot were6.87, 20.00, 37.44 and 1.46 (mg/l) respectively. From the results obtained, it is observed that sodium has the highest concentration in the irrigated plot while magnesium has the lowest concentration value. Sodium concentration was found high whereas magnesium gave lowest concentration in the control plot. The concentration of Ca^{2+} and Na^+ were slightly different from each other for both irrigated and control plot. This finding concurs with work conducted by Chemura *et al.* (2014).

Table 1: Mean Concentration of Soil Exchangeable Bases in Chanchaga Irrigation Scheme I

Soil Exchangeable Bases	K^+ (mg/l)	Ca^{2+} (mg/l)	Na^+ (mg/l)	Mg^{2+} (mg/l)
Irrigated plot	14.82	40.00	58.65	8.40
Control plot	6.87	20.00	37.44	1.46

3.1.2 Soil SAR and ESP

Table 2 shows the Mean values of soil pH, EC, SAR and ESP for Chanchaga irrigation scheme1. The pH, EC, SAR and ESP of the irrigated plot were 7.33, 0.624(dS/m), 10.68, and 48.13% while that of control plot were 6.50, 0.079(dS/m), 3.49 and 56.93% respectively. The pH value shows that the soil in the irrigated plot was alkaline whereas the control plot was found to be acidic. The values of electrical conductivity and sodium absorption ratio of the soil in irrigated plot were higher than that of the control plot but the exchangeable sodium percentage in the control plot was higher than that of irrigated plot.

The values of 48 % and 56.93% on both irrigated and control plot depicted that the ESP was ranked excessive on control plot followed by irrigated plot. The higher ESP value obtained in results came due to the distance (540m) of the control plot to the river and this means that river Chanchaga was the source of the sodium concentration such as hospital wastes. This study implies that the soil experienced dispersion resulting in poor physical condition and poor plant growth due hospital wastes discharge into river Chanchaga. According to the EC values obtained, the study shows that the salts were ranked low (0-2) on the irrigated plot and the soil was sodic which has very little chance of injury on all plants. Based on the EC and SAR values, the soil was sodic on the irrigated soil (Leticia *et al.*, 2015). This finding concurs with work conducted by Chemura *et al.* (2014).

Table 2: Mean values of soil pH, EC, SAR and ESP for Chanchaga irrigation scheme I

Parameters	pH	EC (dS/m)	SAR	ESP %
Irrigated plot	7.33	0.624	10.68	48.13
Control plot	6.50	0.079	3.49	56.93

Appendix C shows test for equality variances between, SAR, pH, Temperature and other exchangeable bases. The, SAR, pH, and other exchangeable bases do not show any level of significance because their value were greater than 0.10 meaning that the variances were equal. In addition, the chloride has its value less than 0.10 meaning that there is a significant difference in both irrigated and control plot of Chanchaga irrigation scheme I.

3.2 Determination of Physiochemical Properties of Irrigation Water Samples

Table 3 shows physiochemical properties of irrigation water in Chanchaga irrigation scheme I. The values of Ca^{2+}, Mg^{2+}, EC, SAR, Na^+, temperature, K^+, and the ESP of the scheme were 10.0, 3.70, 0.163, 7.6, 2.18, 5.70, 28, 2.90 and 25.6 respectively. These water parameters were within the limit of FAO (1994) except electrical conductivity, potassium and ESP that have higher concentration. The value conductivity (0.163dS/m) was higher in the river compared to FAO (1994) limits (3×10^{-6}dS/m) meaning that the soil was sodic i.e. sodium hazard. Furthermore, the pH values show that the water was found to be alkaline (FAO, 1994). The potassium concentration of the water was higher than that of FAO (1994) and this shows that the level of potassium in the water was higher and sodic in nature (Leticia *et al.*, 2015).

Table 3: Physiochemical properties of irrigation water samples

Attribute	Irrigation water	FAO (1994) Limits
Ca2+ (mg/l)	10.0	800
Mg2+(mg/l)	3.70	120
EC(dS/m)	0.163	3×10^{-6}
pH	7.6	6.5-8.5
SAR	2.18	15.0
Na+(mg/l)	5.70	920
Temperature (0C)	28	-
K+(mg/l)	2.90	2.0
ESP (%)	25.6	

4. Conclusion

Soil salinity and irrigation water in Chanchaga irrigation scheme I Minna, Niger State was assessed with the aim of to assess the fertility status of Chanchaga Irrigation Scheme I. The study reveals the sodium concentration was higher in the irrigated plot. This study implies that the soil experienced dispersion resulting in poor physical condition and poor plant growth due hospital wastes discharge into river Chanchaga. Based on the EC and SAR values present in the irrigated plot, the soil was classified as sodic. The, SAR, ESP, EC, and other exchangeable values in both irrigated and non-irrigated plot bases have equal variances. This study shows that the level of potassium in the water was higher and sodic in nature. The study concluded that the sodium hazard in both soil and water was found high.

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APPENDICES

Appendix A- General Interpretation of Data on EC and ESP from Saturated Paste Extracts

Interpretation of EC from saturated paste extract.

EC (dS/m)	Salt Result	Interpretation
0-2	Low	Very little chance of injury on all plants
2-4	Moderate	Sensitive plants and seedlings of others may show injury
4-8	High	Most non-salt tolerant plants will show injury; salt sensitive plants will show severe injury
8-16	Excessive	Salt tolerant plants will grow; most other show severe injury

Interpretation of ESP from saturated soil paste extract.

ESP	Rank	Interpretation
0-10	Low	No adverse on soil is likely
10+	Excessive	Soil dispersion resulting in poor physical condition and poor plant growth are likely.

Source: Leticia *et al.*, (2015)

Appendix B: Classification of salt-affected soils using the saturated soil paste extraction: Natural Resources Conservation Service (NRCS)

Class	EC (dS/m)	SAR	ESP	Typical Soil Structural Condition
Normal	Below 4.0	Below 13	Below 15	Flocculated
Saline	Above 4.0	Below 13	Below 15	Flocculated
Sodic	Below 4.0	Above 13	Above 15	Dispersed
Saline-Sodic	Above 4.0	Above 13	Above 15	Flocculated

Source: Leticia *et al.*, (2015)

Appendix C: Test for equality variances between, SAR, Temperature, and Exchangeable bases

Attributes	Levene's Test for Equality of Variances				
	F	Sig.	T	Df	Sig. (2-tailed)
PH	3.734	.125	4.789	4	.009
SAR	3.208	.148	123.916	4	.000
Na	.800	.422	1642.920	4	.000
K	2.462	.192	135.024	4	.000
Mg	.000	1.000	849.973	4	.000
Ca	3.455	.137	34.525	4	.000
ESP	3.734	.125	-66.532	4	.000
EC	.800	.422	0.000	4	1.000
Chloride	8.000	.047	287.182	4	.000